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TO STUDY AND OPTIMIZE THE PROCESS PARAMETER THROW ROLLER BURNISHING PROCESS ON EN19 MATERIAL BY RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Roller burnishing has been investigated to improve surface finish which directly affects component's quality and performance. Examination of many serious accidents involving automobile, has revealed that failure of the first stage crank shaft impacted by high revolving speed and other issues was the main reason caused. Automobile parts material EN19 with its high mechanical properties is used for the first of crank shaft to reduce failure; however, the effects of burnishing on surface properties in terms of surface roughness and surface hardness EN19 have not been well documented. In this research, it is demonstrated that improvement is material properties can be achieved by roller burnishing applied to EN19. Such as smoother surfaces and enhanced surface hardness with a depth of layer. For surface roughness, burnishing pressure, no of passes and speed are significant factors whereas turned surface roughness is negligible. The pressure is the most important factor for both surface hardness, as well as for surface roughness at the surface.

KEYWORDS: Burnishing, EN19 Steel, Surface Roughness, Surface Hardness, Microstructure, DOE, Full Factorial Design & Response Surface Methodology

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Original Article

INTRODUCTION

Roller burnishing is a method of cold working metal surfaces to induce compressive residual stresses and enhance surface roughness qualities. The tooling typically consists of cylindrical roller. These tools are pressed across the part being processed. The part must be moving at a constant rate of speed, for example in the case of roller burnishing a part on a lathe, the part is spinning and the burnishing tool is moved across the surface as a constant rate. It producing a very consistent finish across the part. Shown in figure 1.

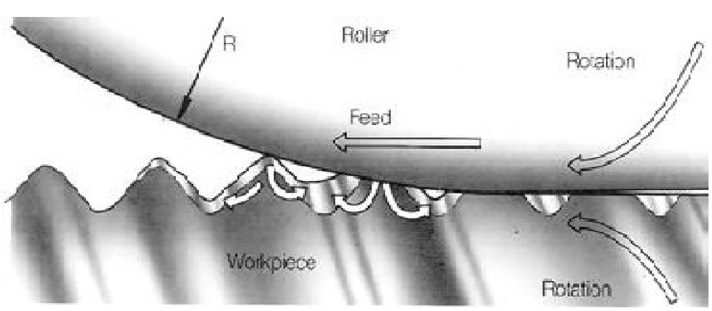

Figure 1: Basic Operation of Burnishing [2]

LITERATURE REVIEW

Mieczyslaw Korzynski, et al, [2] presents an unconventional method of finishing shafts – slide burnishing with a cylindrical ended tool whose axis is perpendicular to that of the worked shaft. They obtain mathematical models – multinomial’s of the second order that also allow for the interaction of input factors. They showed that the Fatigue strength improved compared to that of the ground workpieces by 18%. It was found that those effects can be achieved without a lot of technological effort.

Feng Lei Li, et al, [3] carried out experiment on the geometries of burnishing tool and workpiece by the microscopic topography of the machined surface and the mechanical properties of workpiece. They obtained lowest surface roughness and the optimum burnishing force. They found that the lowest surface roughness is proportional to the initial surface roughness, and burnishing can decrease the surface roughness of workpiece up to about 75% to 87.5%.

M.M. El-Khabeery, et al, [4] determined residual stress distribution in the surface region that was burnished using a deflection-etching technique on 6061-T6 aluminium alloy. They influence three process parameters like burnishing speed, burnishing number of passes and depth of penetration. The maximum value of compressive residual stress decreases with an increase in burnishing speed. The maximum compressive residual stress increases with an increase in burnishing and number of passes or depth of penetration.

Malleswara Rao J. N., et al, [5] found that the surface hardness of mild steel specimens increases with increase in the burnishing force up to 42 kgs Maximum reduction in surface roughness is observed in first five passes on mild steel by Roller Burnishing operation.

Dinesh Kumar, et al, [6] presented on improving Surface Finish and hardness for mild steel cylinder using roller burnishing. They observed that the load required passing the tool increases with increase in interference and Surface hardness also increases with interference increases. They observed that the average improvement in surface finish with interference 120 um was 93.4 % and average increase in hardness with interference 80um has been observed 22 %.

P Ravindra babu, et al, [7] investigated on the surface Characteristics, surface microstructure and micro hardness through various process parameter such as burnishing speed, burnishing force, burnishing feed and number of passes on EN Series steels (EN 8, EN 24 and EN 31), Aluminium alloy (AA6061) and Alpha-beta brass material. They found that the minimum roughness are 535 rpm, 200 N, 0.063 mm/rev for EN 8 and 355 rpm, 200 N, 0.095 mm/rev for EN 24 and EN 31 alloy steels for optimum speed, force and feed respectively.

From the literature review of previous works on burnishing reveals that only, a few researchers concentrated on the analysis of roller burnishing process dealing mostly with the surface finish and hardness, but with little focus on the optimization of burnishing parameters. Furthermore, it has been not much study carried out on burnishing of EN19. Thus, there is very less work carried out on EN19 so it has been decided to work on EN19 material with consideration of their importance in industrial and automobile field. The current study will aimed at optimizing and analyzing the burnishing parameters, namely, burnishing speed, feed, force and number of passes using full factorial method. The influence of burnishing parameters on output responses surface roughness and surface hardness in this study.

RESEARCH WORK-OUT

Figure 2: Bright Centerless OD Roller Burnishing Machine

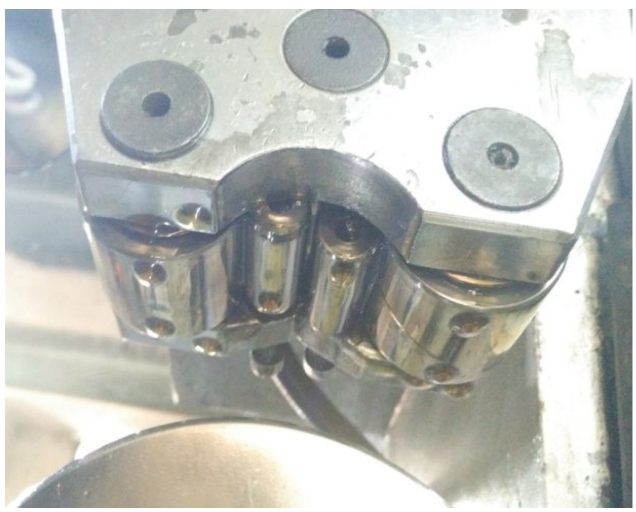

Figure 3: Multi Roller Burnishing Tool

RESULTS AND DISSCUSIONS

Table 1

Sr. No.	Speed (m/min)	Pressure (Bar)	No. of Passes	Ra	Hardness RC
1	20	15	2	0.78	35
2	20	10	3	0.83	35
3	20	15	1	0.79	34
4	20	20	3	0.74	38
5	16	10	3	0.81	37
6	10	15	1	0.77	36
7	20	10	1	0.90	32
8	10	20	3	0.66	39
9	20	15	3	0.73	35

Table 1: Contd.,					
10	10	20	1	0.74	38
11	20	20	2	0.76	37
12	10	10	1	0.79	35
13	16	10	1	0.88	34
14	10	15	2	0.69	37
15	16	15	3	0.71	36
16	20	20	1	0.77	37
17	10	20	2	0.68	39
18	16	20	1	0.76	38
19	16	10	2	0.82	35
20	10	15	3	0.67	38
21	10	10	3	0.68	37
22	16	20	3	0.69	40
23	20	10	2	0.86	33
24	16	15	2	0.76	36
25	10	10	2	0.71	36
26	16	15	1	0.78	35
27	16	20	2	0.71	39

Main Effects Plot for Means of Surface Roughness

The main effects plot for surface roughness versus Speed, Feed rate and No. of passes are shown in Figure 4,

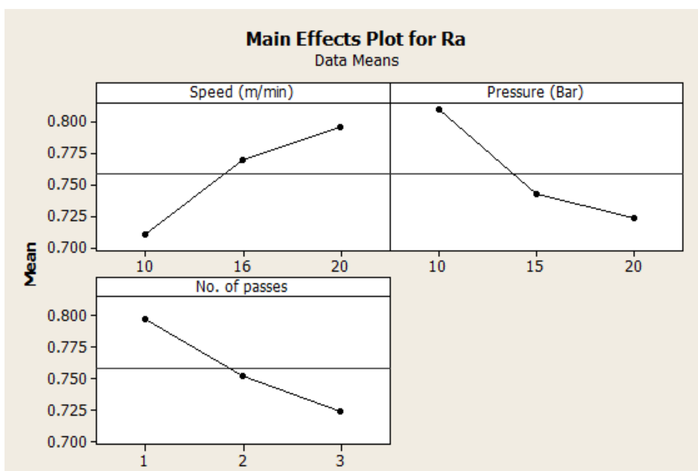

Figure 4: Effect of Control Factor on Surface Roughness

Table 2: Response Table for Means

Level	Speed (m/min)	Pressure (Bar)	No. of Passes
1	0.7100	0.8089	0.7978
2	0.7689	0.7422	0.7522
3	0.7956	0.7233	0.7244
Delta	0.0856	0.0856	0.0733
Rank	2	1	3

Figure 4 shows that lower surface roughness will meet at Speed 10 m/min, pressure 20 and No. of passes 3. It has been conclude that the optimum combination of each process parameter for lower surface roughness is meeting higher Pressure, lower Speed and higher No. of passes**.**

Main Effects Plot for Means of Surface Hardness

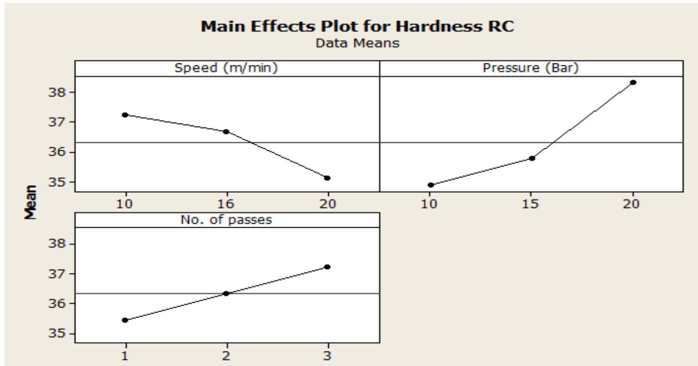

Figure 5: Effect of Control Factor on Surface Hardness

Table 3: Response Table for Means

Level	Speed (m/min)	Pressure (Bar)	No. of Passes
1	37.22	34.89	35.44
2	36.67	35.78	36.33
3	35.11	38.33	37.22
Delta	2.11	3.44	1.78
Rank	2	1	3

Figure 5 shows that higher surface hardness will meet at Speed 10 m/min, Pressure 20 bar and No. of passes 3. From the figure 5, it has been conclude that the optimum combination of each process parameter for lower surface hardness is meeting at lower Speed, higher Pressure and higher No. of passes**.**

ANALYSIS OF VARIANCE (ANOVA)

Analysis of Variance for Surface Roughness

Table 4: ANOVA: Ra Versus Speed (m/min), Pressure (Bar), No. of Passes

Factor	Type	Levels	Values
Speed (m/min)	fixed	3	10, 16, 20
Pressure (Bar)	fixed	3	10, 15, 20
No. of passes	fixed	3	1, 2, 3

Table 5: Analysis of Variance for Ra

Source	DF	SS	MS	F	P
Speed (m/min)	2	0.034496	0.017248	28.57	0.000
Pressure (Bar)	2	0.036363	0.018181	30.12	0.000
No. of passes	2	0.024674	0.012337	20.44	0.000
Error	20	0.012074	0.000604		
Total	**26**	**0.107607**			

R-Sq = 88.79% R-Sq (adj) = 85.40%

Table 6: ANOVA: Hardness (RC) Versus No. of Passes, Pressure (Bar), Speed (m/min),

Factor	Type	Levels	Values
Speed (m/min)	fixed	3	10, 16, 20
Pressure (Bar)	fixed	3	10, 15, 20
No. of passes	fixed	3	1, 2, 3

Table 7: Analysis of Variance for Hardness RC

Source	DF	SS	MS	F	P
Speed(m/min)	2	21.556	10778	32.33	0.000
No. of passes	2	14.222	7.111	21.33	0.000
Pressure(Bar)	2	57.556	28.778	86.33	0.000
Error	20	6.667	0.1511		
Total	**26**	**100**			

R-Sq = 93.32% R-Sq(adj) = 91.34%

Response Surface Analysis for Surface Roughness

In Figure 6, Surface plot of surface roughness for interaction of speed and pressure, when no of passes taken as hold value. This surface plot indicates that surface roughness increase in speed from 10 to 20 m/min whereas surface roughness decrease in pressure increase from 10 to 20 bar.

In Figure 7, Surface plot indicates that surface roughness decreases with pressure from 15 to 20 bar, whereas surface roughness decrease with increase no of passes from 1 to 3.

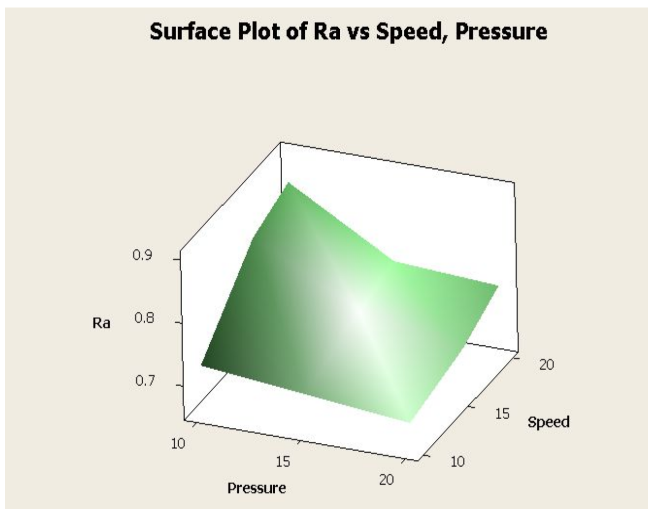

Figure 6 : Surface Plot for Surface Roughness vs. Pressure and Speed

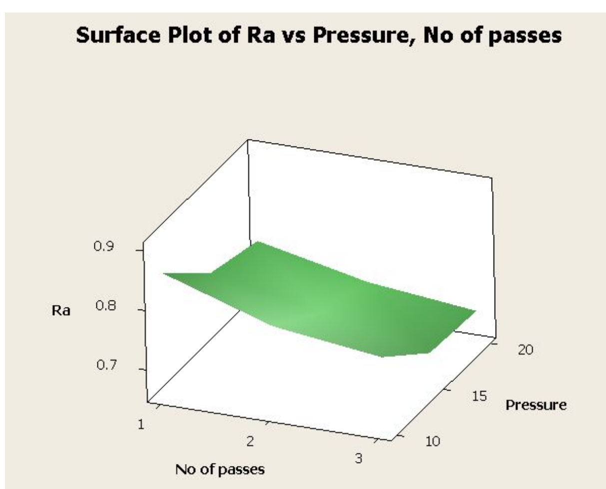

Figure 7: Surface Plot for Surface Roughness vs. Pressure and No. of Passses

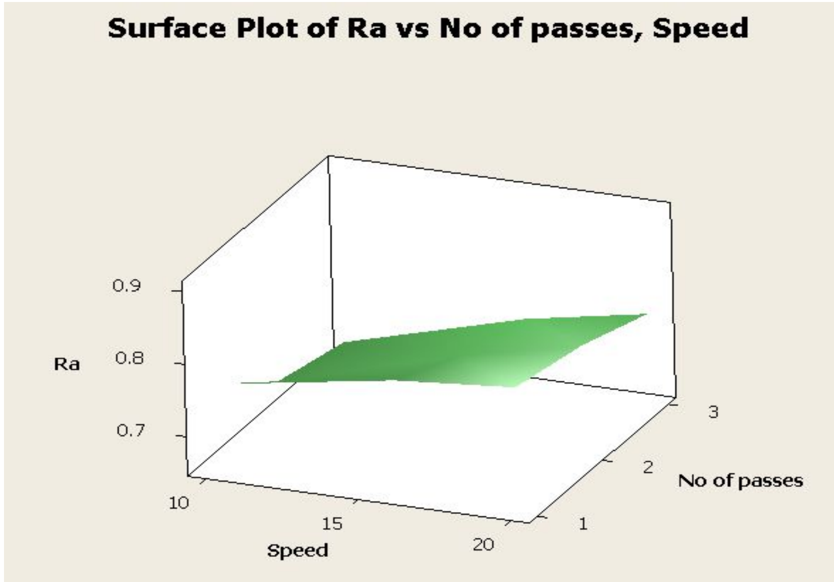

Figure 8: Surface Plot for Surface Roughness vs. Pressure No. of Passes and Speed

Optimization of Process Parameters for Surface Roughness

To determine the optimal setting of process parameters that will minimize the surface roughness with the use of response optimizer in response surface methodology shown in table 8.

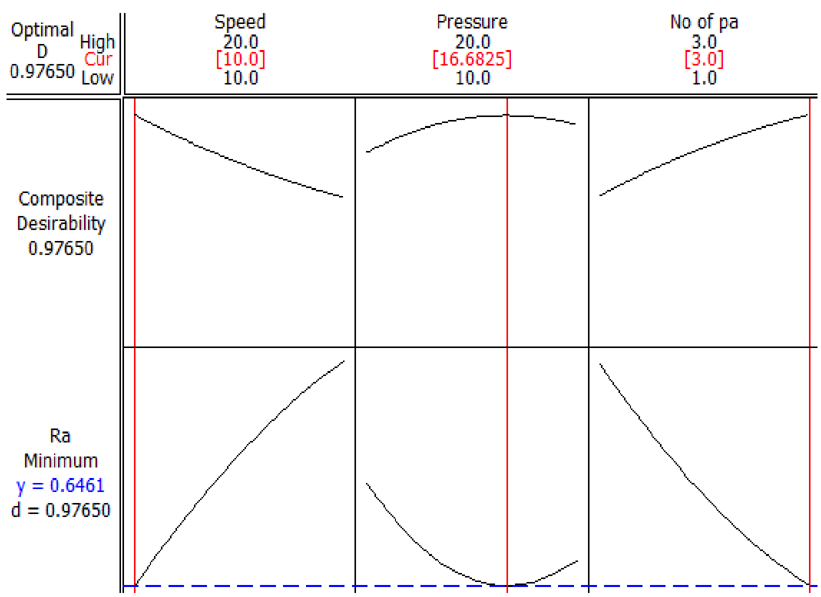

Figure 9: Response Optimization Graphs for Surface Roughness

Table 8: Response Optimization Surface Roughness Parameter

Response	Goal	Optimal Condition	Target	Upper	RSM Predicated	Experimental In
Surface Roughness	Minimize	Speed = 10 Pressure = 16.6825 No of passes = 3	0.64	0.9	0.6461	0.67

Response Surface Analysis for Surface Hardness

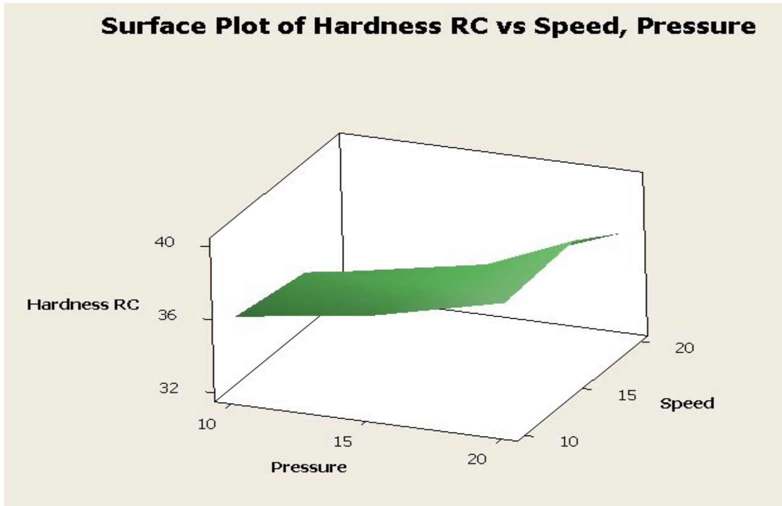

Figure 10: Surface Plot for Surface Hardness vs. Pressure and Speed

In Figure 10, Surface plot indicates that surface roughness increase in speed from 10 to 15 m/min whereas surface roughness increase in pressure increase from 10 to 20 bar.

In Figure 11, Surface plot indicates that surface roughness increases with pressure from 10 to 20 bar, whereas surface roughness increase with increase no of passes from 1 to 3.

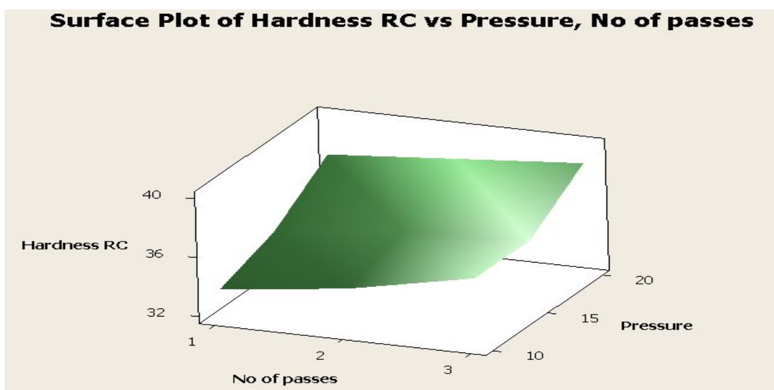

Figure 11: Surface Plot for Surface Hardness vs. Pressure and No. of Passes

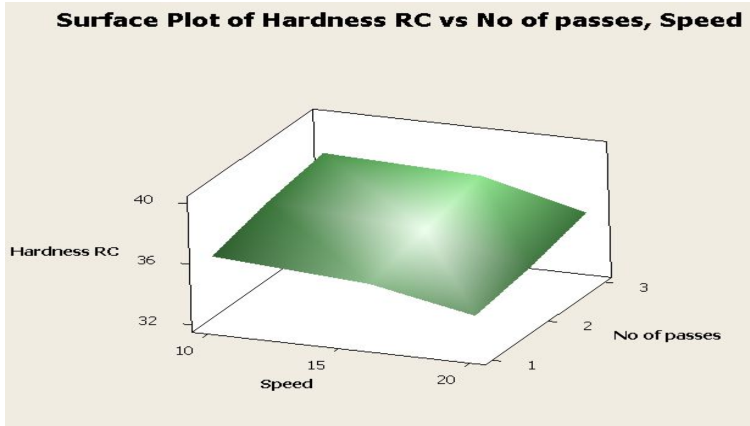

Figure 12: Surface Plot for Surface Hardness vs. No. of Passes and Speed

Optimization of Process Parameters for Surface Hardness

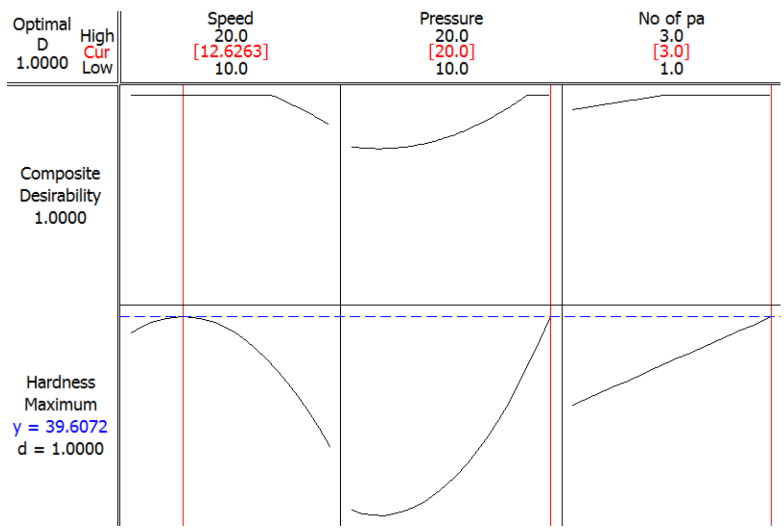

Figure 13: Response Optimization Graph for Hardness

Table 9: Response Optimization Surface Hardness Parameters

Response	Goal	Optimal Condition	Target	Upper	RSM Predicated	Experimental In mm
Surface hardness	Maximize	Speed = 12.6263 Pressure = 20 No of passes = 3	32	39	39.6072	40

CONCLUSIONS

Experimental investigation on roller burnishing machining of EN19 has been done using Design of experiment. From RSM, predicated surface roughness and surface hardness are 0.6461µm and 39.6072MPa and carried out experiment from global solution are 0.64 µm and 40 MPa.

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